MEDICAL THESIS.

ARTERIO-SCLEROSIS AND BLOOD PRESSURE, IN COAL MINERS, WITH A NOTE ON NYSTAGMUS,

BY

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To anyone who practises, as I do, in a district where coal-mining is the only industry, among men one third of whose life is spent underground, where the conditions of work never fail to impress the occasional visitor as not only hazardous but depressingly unnatural, it is surprising that accidents are so few and the general health so good. While this is true, one cannot avoid the impression that surely the mode of life must in some way, however subtle, react on those who continue in it. Such an impression is by no means new, and a considerable amount of literature dealing with the diseases which affect or were supposed to affect Coal-miners, has grown up. As is to be expected, chief attention has been paid to the Respiratory System, especially to Anthracosis and Phthisis. The former is now only of historic interest, while it has been definitely shewn that Miners have no special susceptibility to Phthisis. Indeed the very reverse is the case. Dr. Tatham, Superintendent of Statistics in the Registrar General's Office, (1.) says, "From other diseases of the

(Appendix III)

"respiratory Organs the mortality among colliers dif-
"fers but little from the average, whilst from Phth-
"isis they shew a marked immunity, their mortality
"from the disease being less than half the average."
A table bearing out this statement is given in the Appendix. (A) This table applies to England. For the miners of this district Dr. T.G.Nasmyth (2) has compiled a table shewing that their mortality from Phthisis is very much below the average for Scotland, so that it has been fully shewn that the two diseases regarding which most has been written in connection with Mining have no unfavourable influence on the Miners' average death rate.

It was at one time thought that Anaemia was common among coal miners, but except in association with Ankylostomiasis this does not seem to be correct. Much attention has been given to the latter disease, but so far, only three cases have been discovered in this country among miners. But since the depth to which pits are being sunk, has increased very greatly in the past few years, especially in this district, and the conditions for the development of the worm are becoming singularly favourable, the subject may in the near future become of extreme economic importance.

Another disease to which greater importance is

likely to be attached in the future is Miners' Nystagmus. This is a well known entity and is the only disease which has been definitely attributed to this particular occupation. A note on the subject is appended.

It is now generally held that the conditions connected with a Miner's occupation are as favourable to health as those in the occupation of any other workman, but it should be noted, that after the age of 55, miners in the aggregate die more rapidly than other occupied males, while between 25 and 55 they die less rapidly. (Appendix I. B.)

It has been suggested by Oliver (3) that miners are to a certain extent a picked class, since men whose constitution is not tolerably sound, and whose physique is not fully up to the average, will either select some other occupation or be forced to give up after they have started as miners. This would go to explain their low death rate between 25 and 55. With regard to the other side of the question, the relatively rapid decay after the age of 55, Tatham (4) attributes this to the "arduous nature of their "employment, so that when they are barely past the "prime of life many of them become enfeebled, and "subject to a mortality which is considerably in "excess of that incidental to other occupations."

H.H.S. Cunynghame, C.B., Assistant Under Secretary for the Home department, also stated (1) that an eight hours day would probably be no gain for the health of the men, unless it might affect those who die under 20, and over 55. "There is a "curious falling off over 55; whether it is the "severe labour done during life, or other causes, I "do not know. It may be argued that these figures "are due to this: that under 20 there is employment "of boys; and that when over 55, it (the increased "mortality) is the result of the rather severe, "almost competitive work which has been done, which "has told upon their health."

But these statements must be received with some hesitation, as it cannot be held that the actual physical exertion of the miner is much in excess of that entailed in many other occupations.

Another explanation of this anomaly in the death rate is advanced in this Thesis.

There is no reference in the literature to Arterio-Sclerosis or Blood Pressure among Coal-miners. In the ordinary examination of miners, especially candidates for Life Insurance, I have frequently been surprised to meet cases of arterial thickening even in quite young men, and this suggested to me that a systematic examination of the Circulatory

System in any considerable number of coal-miners might be of interest.

The subject of the clinical estimation of Blood Pressure has been prominently before the profession of late years. But while innumerable observations have been carefully made in healthy and unhealthy individuals under almost all conceivable conditions, notably by Erlanger, Janeway and Crile, few steps have been taken to satisfy the need for a systematic record of the Blood Pressure in men following the same occupation.

So far this has only been done by Jellinek (5) who examined 532 healthy soldiers, and Tschigajew (6) who has studied the mean arterial Blood Pressure in Russian peasants and in labourers in the Iron Foundries.

This Thesis has been written as the result of the examination of 500 Coal-miners, taken consecutively in the Surgery, none of whom were complaining of symptoms referable to their Circulatory System, with a few exceptions which are specially noted. As a matter of fact the majority were literally taken in "off the street" for the purpose of this enquiry. The examinations were carried out in conjunction with my brother, Mr W. Arnott Dickson, F.R.C.S.,E.

In what follows I have observed the following

arrangement:-

The method of examination and the instrument used are described. The results obtained are given, and exhibited in tabular form. Thickening of the arteries is first taken up, with the various theories promulgated. Next follows Blood Pressure and the conditions affecting it, with particular reference to Arterio-Sclerosis. The commonly accepted causes of Arterio-Sclerosis are then discussed and my own conclusions given.

METHOD OF EXAMINATION.

The examinations were carried out as a rule in the evening between 6 and 7 o'clock: a few were done in the morning between 9 and 10. All the men had been off work for at least four hours, and no man was examined immediately after a meal.

The routine procedure was as follows:- While the man was standing, his pulse rate was counted, the condition of the wall of the Radial Artery was noted, and he was examined for Nystagmus. He was then directed to lie down, when particulars of his habits as to alcohol, meat, and tobacco were obtained, and the conditions of his work noted. His medical history was enquired into, special attention being paid to specific fevers and syphilis.

The chest wall was then exposed and the apex beat located, the cardiac dullness mapped out, and the different areas auscultated. The pulse was again counted. The patient was then seated on a chair, the left arm bared to the shoulder, and the Blood Pressure taken.

In a limited number of cases, a Blood count was then done and a Haemoglobin estimation made.

INSTRUMENT.

The instrument employed for Blood Pressure estimation was Mummery's Modification of Riva Rocci's Sphygmomanometer with the 12 c.m. armlet. This instrument is fully recognised as possessing all the essentials for accurately determining the maximum Blood Pressure, and in a majority of cases for giving at least an approximate determination of the minimum Blood Pressure. These essentials are described fully by Janeway (loc. cit.)

The cuff was adjusted to the left upper arm, with the forearm resting on a table, so that the Blood Pressure was taken as nearly as possible at the level of the heart. Care was taken to have the muscles quite relaxed. With the left forefinger on the Radial, the pressure in the Manometer was raised until the pulse disappeared, and then gradually

lowered until pulsation returned, and the level of the mercury when this occurred was noted. (= Systolic Pressure by method of obliteration.) This was repeated to ensure accuracy.

The pressure in the Manometer was then allowed to fall by stages of five m.m. until the lowest point of maximum oscillation of the mercury column was determined, time being allowed after each fall in pressure for the mercury to regain its utmost oscillation before comparing with the previous level (= Minimum Blood Pressure).

No reading of the minimum Pressure was taken if the pulse was rapid, or the maximum excursion of the mercury less than five m.m.

According to Gumprecht, (8) the maximum reading gives the maximum lateral pressure in the aorta; the minimum reading gives the minimum lateral pressure of the artery explored; and as in the larger systemic arteries the lateral pressure, especially the diastolic, closely approximates that met with in the Aorta, it follows that Blood Pressure readings approximate to to the maximum and minimum Pressure in the Aorta. These conclusions were verified by Erlanger (9), by examinations on animals with a cannula in the artery explored (Profunda Femoris) connected with a manometer to determine the intravascular pressure.

The majority of the men examined were of the phlegmatic type, so that little effort was required to secure the psychical repose which is so desirable in taking Blood Pressure readings.

It is interesting to note that in a good many cases, where, from a desire to secure as many readings as possible, records were taken from men immediately after tooth extraction, painful dressings, and the like, the Blood Pressure was invariably above the average, and this has had some effect on the statistical results.

RESULTS.

It may at once be stated that the outstanding feature of this enquiry has been the discovery of an extraordinary prevalence among miners of arterial thickening as evidenced in the radial artery, a prevalence hitherto undiscovered and apparently unsuspected.

Of the 500 miners examined only 44 had arteries which could not be palpated, i.e., 9%. The remaining 456 (91%) had definitely palpable arteries.

There is of course no difficulty in determining when an artery is thickened. It is, as has been said, as easy to feel a thickened artery as it is to feel a rubber tube; the difficulty arises when one attempts

to convey an idea of the amount of thickening present. The ordinary clinical descriptions - slightly thick - thick - very thick, and the like, are so indefinite that I have for the purpose of tabulation attempted to classify arteries as follows:-

"A". An artery the wall of which cannot be detected by the pulp of the examining finger.

"B". An artery whose wall can be flattened by the finger but can then be <u>easily</u> felt in its entire breadth, like a piece of thick tape. This is a "thick" artery.

"C". An artery whose wall rolls readily under the finger like a piece of thick rubber tubing, and can be flattened only with difficulty. It is always Tortuous. This is a "very thick" artery.

"D". Is applied to that type of artery which shews marked calcareous degeneration, and to which Dr Gibson has aptly applied the term "ipecacuanha root".

For gradations between these thicknesses the terms + and - have been added to "B".

Cases illustrating these groups have been examined by Dr Gibson and other clinicians, who corroborated the description of each group.

No attempt was made to measure the actual size

of the arteries, and the description applies solely to thickness.

TABLES OF ARTERIES.

The total number of arteries classified under each group is as follows:-

"A".	44.	"C".	29
"B-"	110.	"D".	2.
"B".	208.		
"B+".	107.		

The above list conveys an idea of the general type of thickening that has been met with most frequently. By far the largest group is "B", which stands for a "thick" artery. A large number of cases fall just short of the standard laid down above for this group, or are over it, e.g., the arteries in the large group labelled "B-" might be described as "distinctly thickened." Cases going on to great thickening were comparatively few in number. Since the age factor enters so largely into the question of arterial changes I have arranged the 500 cases according to age as under:-

ARTERIES ARRANGED IN AGE GROUPS.

I. ACTUAL NUMBERS.

Age.	A.	B.-	B.	B.+	C.	D.	Total.
20 & under	16.	30.	64.	6.	-	-	116.
21 - 25.	10.	29.	49.	16.	-	-	104.
26 - 30.	7.	19.	31.	18.	1.	-	76.
31 - 35.	7.	15.	26.	23.	2.	-	73.
36 - 40.	4.	7.	13.	12.	2.	-	38.
41 - 45.	-	5.	8.	16.	5.	-	34.
46 - 50.	-	3.	9.	9.	6.	-	27.
Over 50.	-	2.	8.	7.	13.	2.	32.
	44.	110.	208.	107.	29.	2.	500.

II. PERCENTAGES.

Age.	A.	B.-	B.	B.+	C.	D.	Total.
20 & under	13.8	25.8	55.1	5.1	-	-	99.8
21 - 25	9.6	28.	47.1	15.3	-	-	100.
26 - 30	9.2	25.	40.8	23.7	1.3	-	100.
31 - 35	9.7	20.8	36.	30.5	2.8	-	99.8
36 - 40	10.5	18.4	34.2	31.6	5.2	-	99.9
41 - 45	-	14.7	23.5	47.	14.7	-	99.9
46 - 50	-	11.1	33.3	33.3	22.2	-	99.9
Over 50	-	6.2	25.	21.8	40.6	6.2	99.8

The most salient feature presented by these figures is the very great frequency of arterial thickening in youths of 20 years and under. While the proportion of normal ("A") arteries in that particular group is greater, as would be expected, than in any other, yet to have so preponderating a proportion of thickened radials (100 out of 116 = 86%) in healthy boys of 14 to 20 years is exceedingly striking, and of these 100, no fewer than 64 had arteries so thick as to be classified as "B", while there were other six for whose arteries even that description was inadequate.

After the age of 40 none of the cases had arteries which were not palpable. With increase in age there is a gradual and uninterrupted progression in the thickening of the arteries. The percentage of arteries classified as "B", or thicker, is as follows:-

At 20 & under . . .	60.2%
21 - 25 . . .	62.4%
26 - 30 . . .	65.8%
31 - 35 . . .	69.3%
36 - 40 . . .	71. %
41 - 45 . . .	85.2%
46 - 50 . . .	88.8%
Over 50 . . .	93.6%

PATHOLOGY OF ARTERIAL THICKENING.

Arterial thickening as evidenced in the Radial Artery may be due to three different conditions.

1. Arterio-Sclerosis.
2. Atheroma.
3. Hypertonus.

1. ARTERIO-SCLEROSIS.

The term Arterio-Sclerosis has been applied in so widely differing senses that it is essential to define the condition which is here referred to under that name. It may be described in general terms as a diffuse organic thickening of the arterial wall perceptible to the sense of touch, and extending as far as the artery can be traced.

The origin of the term Arterio-Sclerosis is of comparatively recent date. Before it came into general use in this country all arterial thickenings were described as Atheroma, while now most authors have adopted the newer term to the exclusion of the old, and describe these changes as Arterio-Sclerosis. A distinction is always drawn, however, between the nodular or focal variety, to which the name of Atheroma should be applied, and the diffuse form, to which it is better to limit the term Arterio-Sclerosis.

Regarding the microscopical changes and the order

of their development in Arterio-Sclerosis (that is, the diffuse form) many opinions have been put forward. Possibly this is due to the fact that most observers have described fully developed cases, and drawn their deductions from these. But as Clifford Allbutt has remarked, the artery is then in ruin, and it is very difficult to say exactly along which path it has come to grief.

For example, Thoma (10) describes degeneration of the media and thickening of the intima due to the formation of new connective tissue in the subendothelial layer. He holds that the condition originates in the media by degeneration of the muscle fibres, that consequent on this there is dilatation of the vessel with slowing of the blood stream, and that the thickening of the intima is purely compensatory. This theory has the support of Osler (10) Councilman (11) & Mott (12). Savill (13) contends that the condition is essentially a muscular hypertrophy without thickening of the intima, and designates it hypermyotrophy. Russell (14) describes hypertrophy of the middle coat, and fibrous hyperplasia of the intima, without atheromatous degeneration, with sometimes thickening of the adventitia. Cowan (15) describes an alteration in all three coats. "The intima is thickened, with great hypertrophy of the elastic fibrils, and later, de-

"generation. The media is always abnormal, it may be "atrophied or hypertrophied: the adventitia is in- "variably thickened, and this is the only constant "change."

Clifford Allbutt (16) insists that Arterio-Sclerosis is a pathological result; not a disease but the result of many diseases, any of which may singly or together, be the cause of it. Even from a strictly pathological point of view he holds that it is not a single condition, but certainly dual and probably multiform.

II. ATHEROMA.

This term is here used to describe Arterial thickening which is always focal or circumscribed, and is always early associated with degeneration, fatty or calcareous. All recent writers are agreed that the change is primarily intimal, with hypertrophy of the connective tissue and no alterations in the media or adventitia, at least in the earliest stages. Later, when degeneration occurs, these layers may be affected. It is comparatively rare in the radials, and never uniformly affects the whole circumference of the vessel, or long stretches of it.

III. HYPERTONUS.

This term has been introduced by Dr William

Russell to describe a vessel "the muscular coat of "which is unduly contracted, so that the wall is thicker "and the lumen smaller." Such a vessel feels thicker than a normal artery, the degree of thickness varying with the amount of contraction. This thickening is commonly a uniform one, but may take the form of "rings", "plates" or "segments." The uniformly contracted artery is, according to Russell, very commonly mistaken for Arterio-Sclerosis, while the other and less common variety is usually regarded as Atheroma. As it seems to be quite impossible to tell by the finger alone in <u>every</u> case when an artery is organically thickened, or when it is merely in a state of hypertonic contraction, the discussion of this condition will be deferred to a later point, i.e., when the relation of Arterial thickening to Blood Pressure is taken up.

PATHOLOGY OF MY CASES.

I have recently obtained specimens of four Radial Arteries from men who met with fatal accidents. Dr. L.R.Sutherland, Professor of Pathology in the University of St Andrews very kindly examined these for me, and reports as follows:-

"After hardening in absolute alcohol, a series "of sections from different levels was made in each "case. Haematoxylin and Eosine, and Weigert's elastic "stain were mainly used.

"Case I. (From a man aet. 27) Localised thick- "enings of the intima are readily observed. In some "sections as much as one third of the lumen is invol- "ved: in others only a small patch is seen. In the "latter case the patches rise more or less abruptly "from the wall: in the former the thickening gradually "shades away into the normal intima. Some of the "patches are six times as thick as the normal intima. "The thickened tissue is of more or less open texture, "and is tolerably cellular. There is no evidence of "fatty degeneration, or calcareous infiltration, but "here and there slight hyaline changes are noted. The "fenestrated membrane of Heule underlying the thick- "ened patches, shews often flattening and thinning, "and in one or two instances is defective. The media "underlying the larger thickenings is atrophied. The

"muscle nuclei in the immediate vicinity shew defec-
"tive staining, and the elastic tissue is irregular
"in its disposition.

"CASE II. (From a youth of 16 years). The
"thickening of the intima is here slight, involving
"either a continuous tract amounting to one fourth of
"the lumen of the artery, or less commonly appearing
"in the form of a localised prominence. Nowhere is
"the thickening more than thrice that of the normal
"intima. The appearances otherwise are similar to
"those in Case No. I, only less marked in degree.

"CASE III. (Man aet. 38). Here the changes are
similar to those in Case I, only more marked. Some of
"the patches have ten times the thickness of the nor-
"mal intima, and as much as one half of the lumen of
"the vessel may be involved.

"CASE IV. (Man aet. 65). There is well marked
"and widespread thickening of the intima, involving in
"some cases fully two thirds of the lumen, and at-
"taining the thickness here and there of twelve to
"fifteen times that of the normal intima. The thick-
"ened tissue is tolerably cellular, the nuclei stain-
"ing for the most part sharply. Here and there faint
"granularity is noted, as from early fatty degenera-
"tion. Occasional deficiencies are observed in the
"fenestrated membrane. There is atrophy of the media,

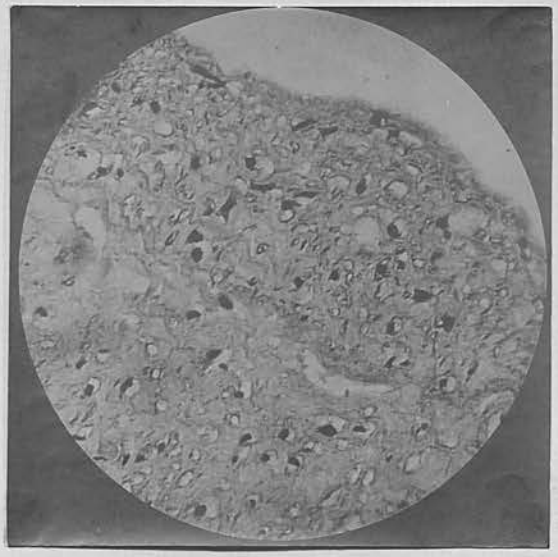
"but the most striking alteration, seen particularly "in sections stained in Haematoxylin, is extensive "calcareous infiltration of this coat. The lime is "deposited mainly in finely granular form, but here "and there crystalline masses are visible. Occasion- "ally three calcareous patches are found in a single "section. In one or two places these involve fully "one sixth part of the muscular coat. There is no "evidence of ossification."

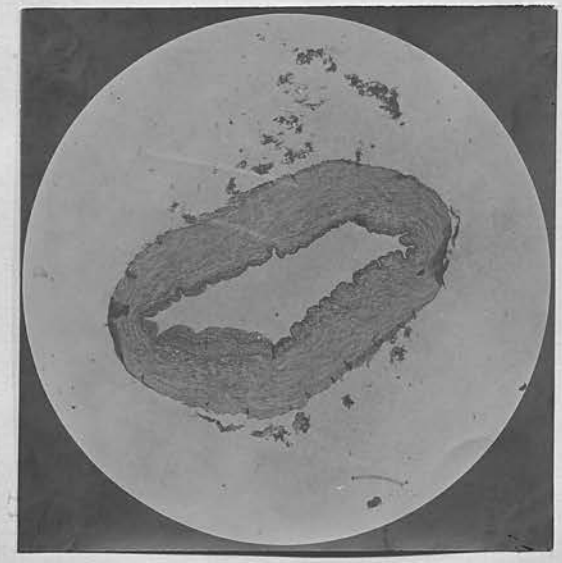
Microscopic photographs are added.

In fig. I, a thickened patch of medium size is shewn at the giving off of a small branch.

In fig. II, the tissue of the patch stains readily, as shewn here, taken from the inner part of one of the largest patches. Considerable defects in the fenestrated membrane of Heule occur. The tissue of the muscular coat bordering on the patch sometimes shews a granular appearance.

Figure III, is similar to figure I.





These reports give a clear indication of the pathological condition of the arteries in the cases I have examined. It will be seen that the thickening is in the Intima, and that it does not involve in any of the sections examined, the whole circumference of the vessel. There is no evidence whatever of thickening of the muscular coat or adventitia. Regarding the calcareous degeneration in Case No. IV, occurring in a man aet. 65, Professor Sutherland was of opinion that this was simply a senile change superadded to an earlier intimal thickening. So far as I can discover arterial changes, similar to those, have never before been described.

BLOOD PRESSURE.

As Blood Pressure in healthy individuals varies within certain not yet accurately defined limits not only in different individuals, but to almost as great a degree in each individual under the influence of various conditions, there can be no fixed standard of normal Blood Pressure. Nevertheless it is necessary to establish limits within which Blood Pressure should be regarded as normal. It is desirable at this point to enumerate various conditions which should be taken into account in judging the value of Blood Pressure statistics, taken from healthy individuals.

(1) Age. That there is a tendency for Blood Pressure readings to increase with age is generally admitted. Though the cause of this "quasi-normal" rise has been variously assigned, "at least it is due "to increasing peripheral resistance, whatever be the "more remote causes." (Janeway loc. cit. p. 109), so that after the age of 50, the average readings are considerably above those of young adults.

(2) Occupation. The influence of occupation has been little studied, Gumprecht, quoted by Janeway (loc. cit.) found in men accustomed to hard manual labour, figures similar to those that obtain in old age. Dr Gibson (17) has pointed out "that it is un- "doubtedly true that all persons who pass through "lives of considerable exertion have a higher Blood "Pressure than those whose expenditure of energy is "on a lower level. The occupation of the individual "is therefore to be taken into account in all Blood "Pressure readings."

Mott (loc. cit. p. 321) quotes Tschigajew, who has studied the Blood Pressure in Russian peasants while engaged in long and continuous work in the fields during the summer, and while at rest during the winter. During the period of work, there was increase of Blood Pressure, but this gradually disappeared in the winter. He compared these results with

his observations on men in the Iron Foundries, who work continuously under unhealthy conditions throughout the year. In the latter class he found permanently high Blood Pressure.

(3) Arterio-Sclerosis. The relation of this to Blood Pressure is discussed under a separate heading.

(4) Temperament. The psychical difficulty is one which must never be overlooked, for single measurements are often unduly influenced by excitement or apprehension, and it is not always possible to be certain that we have secured that placid mental condition which is essential to the accuracy of the reading.

All writers on the subject agree in this influence in raising the Blood Pressure, and in a private communication from Clifford Allbutt he mentions that in many cases the readings after 20 minutes, when the patient's mind and body are perfectly at rest, are 20 m.m. lower than before, so that in a series of readings taken consecutively, such as mine, certain allowance must be made for the influence of this factor in a fair number of cases.

NORMAL LIMITS OF BLOOD PRESSURE.

90 m.m. of mercury with the 12 c.m. armlet, is accepted by most authorities as the lowest systolic pressure consistent with health in adult males; while

145 m.m. is usually taken as the greatest systolic pressure which should be regarded as normal.

In the great majority of healthy young males 100-130 m.m. will be found. (Janeway loc. cit. p. 108).

According to Gibson (loc. cit.) in young adults the normal systolic pressure does not exceed the limits of 90-140 m.m.

Leonard Hill quoted by Russell (18) places the pressure in the brachial artery of a healthy young man at from 110-130 m.m.

Theyer (Janeway, loc. cit.) gives tables of Blood Pressure of 276 healthy individuals arranged by decades, taken with the 5 c.m. armlet.

37	cases	1-10	years	averaged	104.6
87	"	10-20	"	"	128.7
89	"	20-30	"	"	136.9
37	"	30-40	"	"	140.8
20	"	40-50	"	"	142.2
5	"	50-60	"	"	154.8
1	"	60-70	"		180.

The most recent work on the subject is that of Oliver, (19) in which he states that, "disregarding "the causes of physiological disturbance, the limits "of systolic Blood Pressure for the normal man are "from 90-145 m.m."

From these authorities, it is a fair conclusion that 100-130 m.m. of mercury will include the systolic Blood Pressure of the great majority of healthy adults, at least up to middle life.

The estimation of the diastolic pressure in my cases was discontinued after about 200 readings were taken, as it was apparently of little significance so far as this enquiry is concerned. It was practically invariably from 25-40 m.m. below the systolic pressure, as has been found by other observers.

I have tabulated the Blood Pressure according to age as under:-

BLOOD PRESSURE ARRANGED IN AGE GROUPS.

AGE GROUP.		BLOOD PRESSURES.					
		100 & under.	100 to 110	110 to 120	120 to 130	130 to 140	over 140
I	20 years and under.	10	23	42	26	8	2
II	21 - 25	3	15	33	28	16	13
III	26 - 30	0	6	31	25	10	4
IV	31 - 35	0	6	28	23	14	6
V	36 - 40	1	2	13	10	11	2
VI	41 - 45	2	2	9	8	9	3
VII	46 - 50	1	2	4	4	9	6
VIII	over 50	0	1	6	4	4	15
	Totals.	17	57	166	128	81	51

368 of the 500 (73.6%) has Blood Pressure falling within normal limits: i.e., below 130.

There were 81 with Blood Pressure
between 130-140 = 16.2%
There were 51 with Blood Pressure
over 140. = 10.2%

or if we accept Oliver's standard "excluding physio-"logical disturbances," we have 449 cases falling within normal limits.

RELATION OF ARTERIO-SCLEROSIS TO BLOOD-PRESSURE.

There exists a general impression that arterio-sclerosis is necessarily associated with increased blood pressure. Thus we have Osler (loc. cit.) stating that "as a rule arterio-sclerosis and increased "blood pressure are found together. The combination "of increased arterial tension, a perceptible thicken-"ing of the artery, hypertrophy of the left ventricle "and accentuation of the aortic second sound are signs pathognomonic of arterio-sclerosis." And Cowan (loc. cit.) asserts that the one common feature of all cases of arterio-sclerosis is the presence of continued high blood pressure.

Hensen (20) gives tables of blood pressure in arterio-sclerosis, which shew an average of 20 m.m. over the normal.

Weiss (20) also found increased blood pressure in arterio-sclerosis and he attributed this to

increased cardiac action from increased peripheral resistance and the rigid vascular walls.

Saville (loc. cit.) described thirty cases of arterio-sclerosis, with increased blood pressure in all. Schule, quoted by Crile, says that in arterio-sclerosis a rise in arterial pressure is the most constant symptom, and is already found at the beginning of the affection.

Von Basch took the view that arterio-sclerosis arising from whatever cause directly produces gradual increase in blood pressure. (21)

Huchard (22) regards arterio-sclerosis as a mechanical condition arising from increased blood-pressure. Russell asserts that thickened arteries never give normal readings. Janeway states that normally the systolic blood pressure in arterio-sclerosis is above average, (from 145 to 160 m.m.): but admits that a considerable degree of thickening of the superficial arteries may co-exist with blood-pressure not above normal.

MY RESULTS.

The result of this enquiry does not bear out the above contention. Over and over again I have met with cases where the arteries were very thick, and the blood pressure well below normal: while on the other

hand, perfectly soft-walled arteries have been found in conjunction with high blood pressure readings.

For example, M.H. aet. 40, had thick-walled and tortuous arteries (C), and his blood-pressure was only 115 m.m., while N.C. aet. 35, with perfectly healthy arteries, whose walls could not be palpated, (A), had a blood pressure of 155 m.m.

There are moreover great variations in blood pressure in arteries of the same degree of thickening, as is evidenced by the subjoined tables.

Case.	Age.	Condition of Radial Artery.	Blood Pressure.
G.McL.	15.	A.	95.
A.B.	22.	A.	150.
N.C.	35.	A.	155.
T.W.	36.	A.	140.
J.F.	24.	A.	130.
A.L.	29.	A.	110.
J.B.	28.	B-	150.
J.G.	55.	B-	182.
J.O'B.	33.	B-	150.
R.W.	22.	B-	130.
J.B.	37.	B-	140.
J.J.	15.	B-	95.
R.C.	18.	B-	103.
C.C.	19.	B-	120.

Case.	Age.	Condition of Radial Artery.	Blood Pressure.
J.McP.	17.	B-	108.
D.P.	40.	B-	118.
W.D.	29.	B-	115.
T.T.	51.	B-	175.
W.G.	18.	B-	98.
J.C.	18.	B.	95.
J.M.	46.	B.	154.
J.S.	23.	B.	145.
J.C.	51.	B.	108.
W.B.	32.	B.	165.
E.McC.	14.	B.	93.
R.D.	65.	B.	118.
J.McC.	27.	B.	135.
M.R.	16.	B.	114.
P.W.	19.	B.	112.
J.McD.	23.	B.	142.
W.C.	19.	B.	95.
W.P.	16.	B.	117.
J.G.	29.	B.	134.
W.A.	21.	B.	85. (on three readings.) (Lowest of the 500.)
C.D.	16.	B.	150.
J.M.	24.	B+	155.
G.D.	34	B+	112.

Case.	Age.	Condition of Radial Artery.	Blood Pressure.
J.L.	33.	B+	160.
W.K.	20.	B+	148.
C.S.	25.	B+	110.
A.B.	46.	B+	95.
R.C.	57.	B+	165.
C.D.	45.	B+	165.
R.G.	46.	B+	115.
J.G.	35.	B+	96.
R.W.	41	B+	109.
J.McF.	26.	B+	145.
A.N.	43.	B+	107.
G.D.	39.	B+	140.
T.McC.	44.	B+	114.
W.N.	29.	B+	125.
J.B.	42.	C.	140.
S.S.	42.	C.	120.
D.T.	65.	C.	112.
J.L.	50.	C.	185.
A.L.	53.	C.	125.
J.R.	53.	C.	158.
M.H.	40.	C.	115.
D.F.	65.	D.	134.
P.C.	73.	D.	230.

I have classified the whole number of the arteries in their relation to Blood Pressure in the following table:-

ARTERY GROUP	No. of Example.	BLOOD PRESSURE. 100 to	110 to	120 to	130 to	140 to	over 140	
A.	44	2	11	14	9	6	2	
B.-	110	5	15	38	31	15	6	
B.	208	9	24	83	48	28	16	
B.+	107	2	7	26	33	23	16	
C.	29	0	0	3	8	8	10	
D.	2	0	0	0	0	1	1	(230)

It will be seen from this table that there is a general tendency for the Blood Pressure to rise with increased thickness of the arterial wall, but from the individual cases mentioned above it is evident that the arterial thickening alone cannot be held responsible for this, and one must assume the presence of some condition or conditions other than the thickening of the artery examined, to account for any increase of Blood Pressure. For example, it is to be observed that this progressive tendency is comparable with the progressive thickening of the arteries already noted as concomitant with advancing years. (v. page 13).

The generally accepted view that thickening of

the arteries carries with it a tendency to higher Blood Pressure, finds a measure of support in the table given above, but the exceptions given are numerous and striking. It has been suggested that the condition of the splanchnic circulation has a very important bearing on the question, and this, along with the actual peripheral resistance in the capillaries has probably more influence on Blood Pressure than the thickening of the artery examined.

It should here be mentioned that in many cases where there was unduly high Blood Pressure, especially if associated with a ringing aortic second sound the urine was examined for albumen (cold nitric test),but with a negative result in every case.

As the views of Dr Russell (18) regarding the relationship of Arterio-Sclerosis to Blood Pressure have recently attracted a great deal of attention, it seems advisable at this point to discuss in some detail the position which he has taken up.

He admits that the advent of the Sphygmomanometer in clinical work has awakened in the minds of many experienced physicians a grave doubt as to their ability to gauge Blood Pressure consistently by the finger. Some clinicians have discarded their old standards,and assumed that the instrument exposed and corrected their fallibility, while others, obtaining results

widely at variance from the results which the older methods of examination would have suggested, have come as Russell says, to put away the Sphygmomanometer almost with contempt. It certainly seems difficult to reconcile these positions, and it must be admitted that the controversy gathers round the fundamental question as to whether or not it is blood pressure which is measured.

Russell asserts definitely that it is not, and it is on the part played by the vessel wall in the mechanical determination of Blood Pressure that Russell builds up his whole position, and this is the very essence of his contributions to the discussion. Thus he says, in discussing the use of the Riva Rocci instrument (p.49.) "Above all, it would seem reasonable "to assume that the physical characters of the artery "will materially influence the result. That it is compressibility which is determined cannot really be de- "nied; and this being so, it is a matter of common "knowledge that the compressibility of a tube depends "upon the thickness of its wall and the relation be- "tween that and the size of its lumen; and yet it is "taught that the compressibility of an artery as meas- "ured by the haemomameter is literally "Blood Pres- "sure." The revolutionary nature of the newer view seems to have been only partially realised. It is as

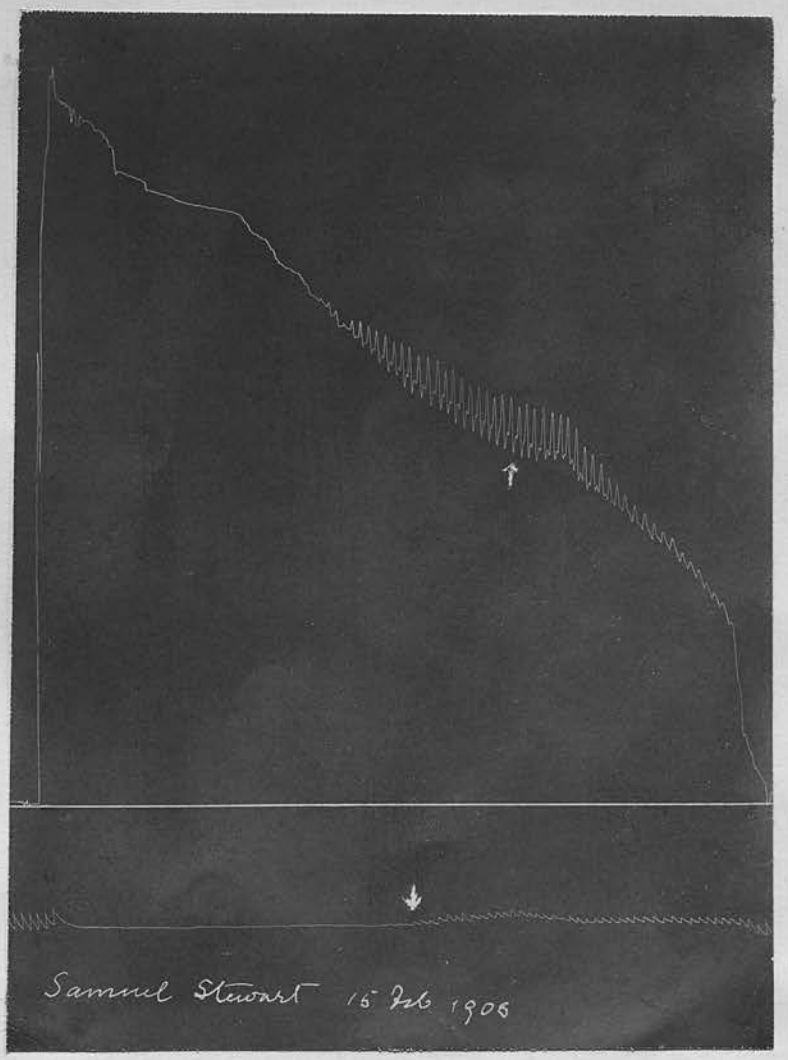
"unsound pathologically as it is clinically." Again (page 68) "thick walled arteries never give normal "readings," and (page 72) "when the radial is thick- "ened from structural changes the pressure remains "constantly above normal."

The closing sentence of this book is "The clini- "cian must recollect that, given thickened vessels, "the instrument records not Blood Pressure, but ar- "terial resistance."

Such a conclusion is opposed to the findings of V. Basch, Erlanger, and Janeway; and Clifford Allbutt informs me that along with Dr. Herringham he has constructed, "under the eye and aid of the Professor of "Physics at St. Bartholomew's" an instrument to test Russell's result, and finds himself in agreement with these earlier observers, that the arterial wall never goes for more than 5 - 8 m.m. mercury.

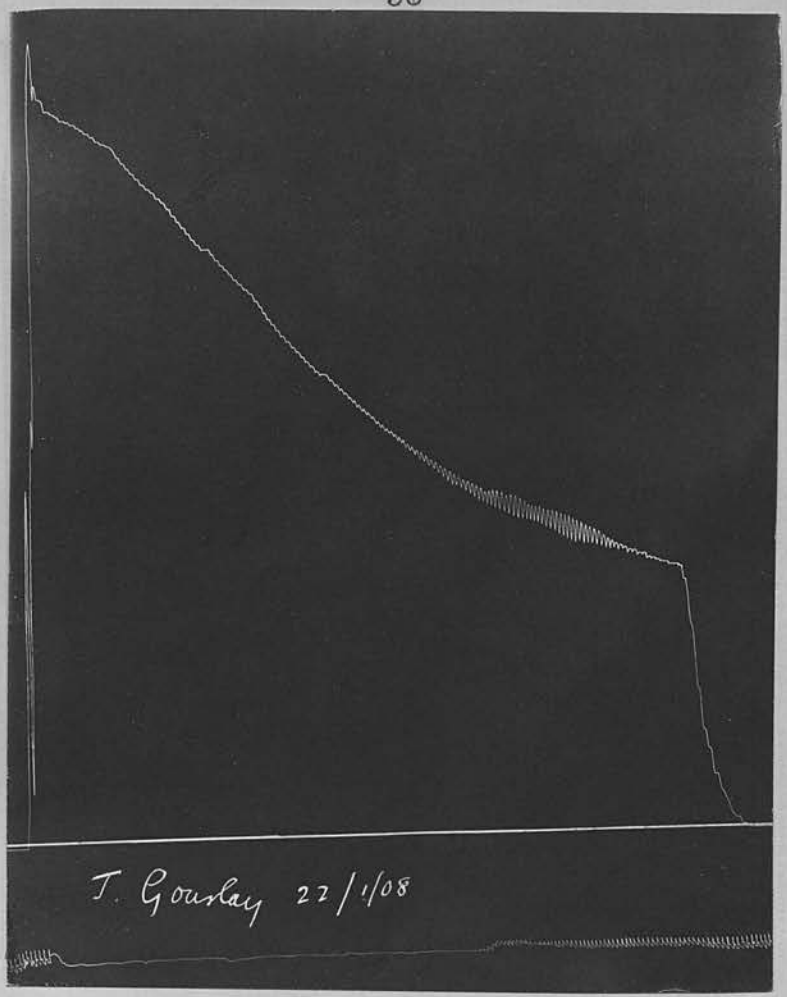
The facts I have established from the clinical side with regard to the relation of Arterio-Sclerosis to Blood Pressure reinforce the objections of these experimental observers to Russell's position: for though over 90% of the arteries shewed more or less thickening, the Blood Pressure readings in the large majority were normal, and in particular such a case as the following must in itself dispose such an assertion as "thick walled arteries never give normal readings."

Case of J.G., aet. 33, whose arteries are B+ and whose systolic Blood Pressure is only 95 m.m. This artery was described by Dr. G.A. Gibson as "very thick" and he very kindly made a tracing of the Blood Pressure for me, which is appended. (h.38)



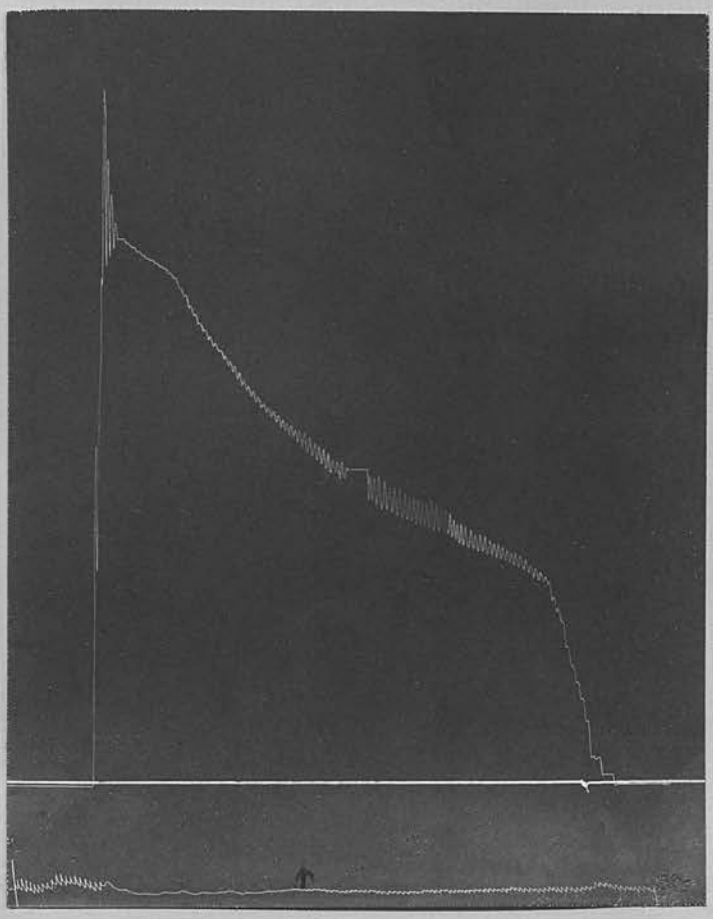
The instrument with which this tracing was taken has been recently devised by Dr Gibson and described by him in the Quarterly Journal of Medicine, October, 1907. The chief features are the simultaneous tracing with the sphygmograph, which shews the first return of pulsation after obliteration of the vessel, and the abscissa, from which one can measure the absolute height of the Blood Pressure, without the risk of error due to the personal equation. As in this instrument the manometer is U shaped, the height of the tracing at the first return of pulsation in m.m., must be doubled to give the actual blood pressure.

Reference may also be made to several other such cases as (1) W.C., aet. 19., whose artery is "B" and Blood Pressure 95 m.m. A similar tracing from him is added.(↓39.)



(2) S.S., aet. 42, with "C" arteries, i.e., very thick and tortuous, whose brachial arteries could be felt between the finger and thumb, round and hard like a pencil, and whose blood pressure on several occasions was 118 to 120. A tracing was also made from his arm, but owing probably to mental disturbance, it shews 128 m.m. of systolic pressure.

This tracing is also shewn. h.36.



(3) D.T., aet., 65, with similar arteries to S.S., the previous case, with Blood Pressure of 112.

(4) W.A., aet., 21, with "B" (thick) arteries, and the Blood Pressure of 85 on three different readings. This as already mentioned was the lowest systolic pressure found over the whole 500 cases.

(5) A.B., aet., 46, with very thick arteries, (B+) and a systolic pressure of 95.

Many other cases bearing out the same contention will be found in the tables already given.

Russell (p. 51) explains the fact, which he admits, that sclerosed arteries only require 5 - 8 m.m. of mercury to flatten them, (post mortem), by pointing out that there is an entire loss of tone in the dead vessel, so that it is no longer comparable to the living one: but he says nothing about tone or loss of tone when he establishes from the same post mortem evidence that a healthy artery wall is negligible when taking Blood Pressure readings.

When Dr Russell gets cases which do not bear out his contention that with thick vessels readings are high, he explains them (p. 122) by "assuming" that the condition of the wall of the brachial artery which is the vessel compressed, does not correspond with that of the radial as revealed by palpation. This assumption is disproved by the fact that repeatedly I have noted the condition of the brachial, and found it invariably in correspondence with that of the radial, as would a priori be expected. (v. case of S.S., antea.)

The other point of importance which Russell has raised, i.e., that Blood Pressure rises both in

normal and sclerosed arteries, with contraction of the muscular wall, ("Hypertonus") is of undoubted practical significance, and Blood Pressure readings may be largely influenced by it.

These cases of Hypertonus are no doubt common, and may be recognised, according to Russell, by the fact that they shew thickened arteries and high Blood Pressure, and as a rule are under middle life (p.28). In these the hypertonus can be eliminated by vasodilators such as Trinitrin, and the real amount if any, of Arterio-Sclerosis can then be estimated.

Many of my cases distinctly shewed Hypertonus: in fact, as the great majority of these had normal Blood Pressure, i.e. under 130, it is safe to conclude that most of the others, especially those with readings over 140, and under middle life were examples of hypertonic contraction. This was very evident while making the examination, for being anxious to secure as many readings as possible, I frequently took readings from men who had had teeth extracted, whitlows opened, and the like, and without exception their Blood Pressure was above 130. The mental effect of applying such an instrument as the Sphygmomanometer was sometimes very marked; e.g. the case of J.D., whose artery was large and soft when first felt, and of "B" thickness, and his pulse rate 70.

When the cuff was being adjusted he got extremely excited, and his pulse rate rose to 110. He fidgeted about in the chair, and the cuff had to be removed when the pressure shewed 170 m.m., the pulse wave still being felt at the radial. The artery then was distinctly hard, felt in fact tightened up, and was equal to B+.

Another case bearing out the importance of recognising Hypertonus and its possible elimination was that of P.C., aet 60, who had extremely thick and tortuous arteries, with a rapid and irregular pulse, and Blood P ressure of 185. After a few doses of Liquor Trinitrin, his Blood Pressure dropped to 150, and his heart became practically regular.

Recently I have been attending an old lady (Mrs. M.) aet. 60 whose arteries were thick, and felt tightened up, and whose second aortic was ringing.

She got several one minim doses of Liquor Trinitrin, and that night she "had the best night's sleep" she had had for a very long time: the ringing noises in her head had ceased, while her radial felt distinctly soft.

Russell describes the genesis of Arterio-Sclerosis as at first, irritation of the artery wall, causing sustained or recurring Hypertonic contraction. From this comes increase of Blood Pressure, which

leads inevitably to structural change, in the form of hypertrophy of the Tunica Media, and sometimes of the intima. Such a description may certainly be true of some group or groups of cases, but it does not apply to the particular group which I have described.

It is not until we take up the position of Clifford Allbutt in his writings on the subject that we can reconcile the conflicting results of observations on the relationship of Blood Pressure to Arterio-Sclerosis.

In his paper in "The Hospital" November 16th, 1907, he states that "far back in the Eighties some "had pointed out that Blood Pressures do not always "rise in Arterio-Sclerosis and that pressures fre-"quently do rise in cases apparently free from this "change."

I have found repeated examples of the latter part of this statement, for example, D.F., aged 22, had a radial which could not be palpated, and a Blood Pressure of 150, and N.C., aged 35, had a similar artery, and a Blood Pressure of 155.

Clifford Allbutt goes on to explain that he parted company with Huchard in his views as to the causation of Arterio-Sclerosis, for the reason that in many persons there is Arterio-Sclerosis without an increase of Blood Pressure, or only such increase of

Blood Pressure as is normal or usual in many people over fifty. This was corroborated by Groedel, who demonstrated that in 26% of cases of Arterio-Sclerosis the Blood Pressure is not raised above this quasi-normal standard of the elderly. Arterio-Sclerosis of itself does not raise the Blood Pressure considerably it is something else that causes this rise. In 1894 he, C. Allbutt, classified Arterio-Sclerosis in three kinds.

(1) Hypertonic, with increase of Blood Pressure.

(2) Toxic, in which there is usually no increase of pressure, not infrequently a decrease.

Under toxic conditions which may give rise to this group of Arterio-Sclerosis, he mentions Diabetes, Infectious diseases, Syphilis, and lead poisoning (in which, however, the Blood Pressure may be high.)

(3) Decrescent or Senile Arterio-Sclerosis.

It is surprising that there is practically no reference in the literature of the subject to Clifford Allbutt's position, and so far as I am aware, no one has admitted in writing that these three groups of cases do exist. All my cases of Arterio-Sclerosis can be definitely assigned to one or other of these three groups, with the proviso that some of the cases which he would assign to the first group may fall under Russell's group of Hypertonic contraction. There is no doubt that most of the cases which I have

examined are examples of Clifford Allbutt's toxic group: that is to say, they have thickened arteries with Normal blood pressure.

CAUSES OF ARTERIO-SCLEROSIS.

The subject of the causation of Arterio-Sclerosis is as darkened by conflicting statements as is the pathology, and this seems undoubtedly to be due to the fact that Arterio-Sclerosis is not a clinical entity, therefore no single cause can be traced as operative in all cases. Much discussion has taken place recently regarding its causation, notably at the International Congress of Medicine at Leipsig in 1904, the American Congress, 1904, and at the Pathological Society of London, 1904, and in medical literature articles on this subject are innumerable. The following is a brief resume of the opinions which have been advanced.

RENAL DISEASE.

The association of Arterio-Sclerosis with Chronic Bright's Disease has long been recognised, and it is there almost, if not quite invariably accompanied by an increase of Blood Pressure, taking as evidence hypertrophy of the left ventricle and accentuation of

the Aortic second sound. As none of my cases were subjects of Bright's Disease, the question as to the initial lesion being renal or cardio-vascular need not here be discussed.

OLD AGE.

Age, per se, has in all likelihood not the effect on arteries which one has been accustomed to believe. One often meets with men over 60, whose arteries are not thicker than in many of my cases of boys under 20. Osler lays stress on heredity in hastening the onset of "physiological" Arterio-Sclerosis, attributing this onset to bad material in the arteries to begin with. While this may have an influence in determining Arterio-Sclerosis at an earlier age than one would expect in some instances, I have been much impressed by a good many cases which seemed to me to point to heredity as a retarding influence, i.e. cases which could only be explained by the particularly good quality of the material of which the arteries were composed, so that though they had been exposed to many of the recognised causes the vessel walls were practically unaffected.

HIGH BLOOD PRESSURE. ~~(see Appendix II)~~

This is admitted to be a cause of Arterio-Sclerosis, indeed, according to Cowan (loc. cit.) the one common feature of all cases of Arterio-Sclerosis is the presence of continued increase of Blood Pressure, which he says is now accepted as its immediate cause.

The condition of continued increase of Blood Pressure without Arterio-Sclerosis has indeed received the names of "Latent Sclerosis" (V.Basch) and "Presclerosis" (Huchard). Clifford Allbutt calls it " Hyperpiesis."

It is obvious from the tables already given that this factor cannot explain the cases which I have described.

DEFECTIVE ALIMENTATION.

In the opinion of many authorities this seems to play a definite part in the production of Arterio-Sclerosis. Osler is impressed by the part played by over-eating, absolute or relative, and says that in many cases there is no other factor.

Russell (loc. cit.) agrees that generous feeding, especially if associated with constipation, leads to hypertonus and therefore to vascular changes in a great number of people, and quotes in his book several cases in support of this view.

F.W.Mott (loc. cit.) asserts that in many cases defective metabolism and altered quality of the blood is antecedent to the production of organic changes in the vessels.

Barr (23) emphasises the part played by the Bacillus Coli in producing Arterio-Sclerosis, and states that the excessive use of nitrogenous foods is much more important than, for example, alcohol.

CHRONIC INTOXICATIONS, of extrinsic origin, especial-ly those due to alcohol, lead and syphilis, have long been considered among the important causes of Arterio-Sclerosis, and certain diatheses, among which rheumatism and gout hold the chief place, are also prominently mentioned in this connection.

Opinions as to the effect of alcohol have caused much heartburning. The actual effect in producing Arterio-Sclerosis is difficult to estimate, but is probably much less than is generally held. In fact Cabot of Boston (quoted by Barr loc. cit.) goes the length of saying that "the Alcoholic origin of Arterio-Sclerosis is a myth," and Clifford Allbutt also states (loc. cit.) that he is not convinced that alcohol, not reinforced by other morbific influences, can set up Arterio-Sclerosis. Tobacco, tea, and coffee as factors in the production of Arterio-Sclerosis have all their advocates.

Schott of Nauheim (24) gives as his opinion that tobacco, wine and strong beer are the principal causes of the disease.

The ACUTE INFECTIONS have recently been laid hold of and brought into the list of causes, and apparently with a good deal of justification.

Thayer and Brush expecially (25) have noted the

prevalence of Arterio-Sclerosis in patients after typhoid fever, and rheumatism seems to be the next most important infection in this connection.

MUSCULAR EXERTION.

The effect of hard physical work has been much debated, and while no definite conclusion has been arrived at, it is stated that men such as dock-labourers, coal-heavers and the like, are more prone to Arterial degeneration than those in other occupations, and it seems reasonable to believe that in these whose occupation necessitates violent muscular exertion over short periods, with its consequent influence on Blood Pressure, there may be produced a strain of the arterial walls which sooner or later makes itself evident as thickening. Attention may again be directed to the fact that among experts it is agreed that the actual physical work of coal-miners is not in excess of any class of ordinary workmen, for example, joiners.

An extremely interesting and exhaustive account of the different views as to the causation of Arterio-Sclerosis is given by Cowan in The Practitioner (loc. cit.). He sums up as follows, "Arterial damage may " result from many varied causes - continued high "blood pressure invariably in time affects the vessels,

"and this is one of the most important causes of wide-
"spread disease. High Blood Pressure may be secondary
"to renal lesions or may originate without any renal
"flaw. It is in the latter case the result of alimen-
"tary wrongdoing, excess, relative or positive, of the
"food stuffs or alcohol, intestinal fermentation or
"putrefaction, hepatic, pancreatic or gastro intestin-
"al insufficiency may thus all be the initial fault.
"The arteries may be damaged in various intoxications
"the metallic poisons, lead, mercury, etc., comprise
"one group, and the bacterial toxines, rheumatism,
"typhoid, etc., another. Bacteria themselves may be
"formed in early lesions. Syphilis is a frequent
"cause of local lesions. Severe continued physical
"exertion, however it may act, is probably also a
"causal factor."

These seemingly widely divergent views of authorities as to the etiology of Arterio-Sclerosis seem to me to be reconciled when one takes a much broader view, and considers them all as variations of the one common factor, i.e. a toxaemia. The result of this toxaemia is Arterio-Sclerosis either primary, or secondary to an increase of Blood Pressure. The actual conditions leading to a toxaemia are probably protean in their variety. More than one author admits that a toxic cause which may not be evident is the essential element.

With regard to the etiology of Arterio-Sclerosis present in my cases, the following points were investigated:-

(1) ≠Acute Infections≠.

(2) Meat Consumption.

(3) Amount of tobacco used.

(4) Alcohol consumption.

(5) Conditions of work.

I. ACUTE INFECTIONS.

The total number of cases giving a history of any infectious disease is very small.

(a). There were only six cases with history of acute Rheumatism: each case had been laid up for at least three months. None shewed evidence of any cardiac involvement, the apex beat and sounds being normal in every case. A summary of these cases is given.

CASES WITH A HISTORY OF ACUTE RHEUMATISM.

Case	Age	Condition of Radial	Blood Pressure	Duration of illness.
1. J.M.	35.	B-	130.	4 months in bed.
2. T.B.	31.	B-	118	3 months.
3. M.H.	20.	B.	120.	3 months.
4. P.McD.	19.	A.	105.	4 months in bed.
5. D.C.	31.	B.	115.	3 months.
6. T.G.	34.	A.	110.	5 months.

From this it will be seen that the average amount of thickening of the arteries is actually less than that present in the rest of the cases.

The Blood Pressure also in every case is quite normal so that so far as these cases go the influence of Rheumatism in causing Arterio-Sclerosis may be dismissed.

(b). SCARLET FEVER. Thirteen cases gave a history of Scarlet Fever: but these in every other respect conform with the rest of the cases, so that no conclusions from these cases can be drawn as to the influence of Scarlet Fever.

(c) TYPHOID. Twenty-one cases had a history of Typhoid. A list of these is given:-

CASES WITH HISTORY OF TYPHOID FEVER.

CASE	AGE	CONDITION OF RADIAL	BLOOD PRESSURE
W.B.	18.	B.	126.
J.C.	20.	B.	108.
A.P.	21.	B.	118.
D.M.	22.	B+	135.
R.S.	23.	B.	145.
P.M.	23.	B-	100.
A.L.	22.	B.	112.
H.McC.	25.	A.	132.
W.E.	28.	B-	138.
R.S.	28.	B.	113.
H.S.	29.	B+	125.
A.McD.	29.	C.	162.
R.W.	36.	B.	132.
J.L.	38.	B.	95.
J.B.	32.	B.	135.
W.R.	35.	C.	125.
T.S.	42.	B-	120.
W.W.	50.	C.	140.
A.F.	65.	D.	134.
F.E.	66.	B+	132.
D.T.	65.	C.	112.

There is a distinct increase in the average thickening of the arteries in those who have had Typhoid, but it is impossible to draw any general deductions from such a small number. So far as it goes, however, the above table seems to bear out the conclusions of Theyer and Brush already referred to.

(d) SYPHILIS. Only two cases gave a history of having suffered from Syphilis, and both of these were in men who had served in the Army. It may be remarked in passing, that in my experience and that of neighbouring medical men, Syphilis among miners, except in old Army men, is practically unknown.

These two cases presented no point of special interest.

II. AMOUNT OF MEAT EATEN.

Speaking generally, miners as a class are well-fed, though they are by no means gross eaters. The usual dietary is somewhat as follows:- For breakfast, porridge is frequent, followed by tea with bread and butter, though more commonly ham and one egg or two boiled eggs, with tea, bread and butter, is taken. Each miner carries to the pit a flask with weak tea, and two large slices of bread

and butter, and almost invariably a liberal supply of cheese. For dinner, immediately after the day's work, there is ½ lb. of meat to each man, with potatoes ad. lib. and very often some form of milk pudding: if no pudding be provided there is usually tea with bread and jam. In the evening, the meal consists of tea or cocoa with the usual accompaniments.

The variations from this dietary were few in number. Two men were vegetarians: about twenty had 1 lb. of meat per day, and about the same number had less than ½lb., a good many having occasional porridge for dinner, instead of meat. With these variations there was no corresponding variation in the Blood Pressure readings, or amount of arterial thickening, and the above diet certainly does not suggest any probable explanation of the arterio-sclerosis found.

III. AMOUNT OF TOBACCO USED.

The tobacco is generally smoked, but a small proportion is consumed by chewing, expecially by men working in those sections of the pits where safety lamps are used.

I have arranged the men in groups according to

the amount of tobacco used per week, shewing the composition of each group with regard to thickness of arteries and blood pressure.

Ounces per week.	Number of Men.	condition of arteries. A	B-	B	B+	C	D
0	104	11	20	50	20	3	
1	51	3	10	30	3	4	1
2	163	17	32	64	37	12	1
3	107	9	27	42	25	4	
4	55	4	14	15	17	5	
5	9		2	7			
6	7			6	1		
7	4		2	1		1	
	500						

Ounces per week.	Number of men	Blood-Pressure. 100	110	120	130	140	over. 140.
0	104	4	14	36	28	14	8
1	51	2	7	16	11	7	8
2	163	8	17	50	41	30	17
3	107	2	14	31	23	18	19
4	55	1	3	18	19	8	6
5	9		1	3	3	1	1
6	7	1		3	1	1	1
7	4			2			2
	500						

While examining the cases I formed the general impression that tobacco had no specific influence either on arterial thickening or on blood-pressure: and this impression is amply confirmed by a study of the above tables.

IV. ALCOHOL CONSUMPTION.

The easiest and probably the most nearly accurate method of extimating the amount of alcohol used by an individual, is to ask how much he spends on alcoholic liquors per week. The figures which I have tabulated are as nearly right as it is possible for such a collection to be, as I knew personally practically every man examined, and had a very good idea of his tastes and opportunities.

A surprisingly large number of men did not use alcohol at all. But that is accounted for partly by the large number of youths in that group, and partly also to the influence of two friendly societies run on temperance principles, which have a strong hold in the district.

The alcoholic liquors generally used by miners are beer and whiskey: probably the money spent is about equally divided between these two.

Tables similar to those previously given with relation to tobacco are appended, and they shew

that there is no essential relation between the amount of alcohol used and the amount of thickening of the arteries, or the blood-pressure.

I have therefore come to the conclusion, that alcohol, at least in the cases examined, has little or no effect in causing changes in the circulatory system.

Amount spent on Alcohol per week.	No.of Men	Condition of Radial Arteries. A	B-	B	B+	C	D
0	183	20 15 of these under 20 years of age.	41 24 under 20 years of age.	105	16	1	
1/-	103	8	22	39	27	7	
2/6	77	4	14	25	26	7	1
5/-	46	3	9	11	15	8	
7/6	20	4	4	6	4	2	
about 10/-	18	2	4	7	5	1	
about 15/-	19	2	6	5	5	1	
about £1.	8	1	5	0	1	1	
over £1.	26		5	10	8	2	1
	500	44	110	208	107	29	2

Amount spent on alcohol per week.	No.of men.	Blood Pressure. 100	110	120	130	140	140
0	183	14	30	65	40	23	11
1/-	103	1	4	34	34	14	16
2/6	77	3	8	19	17	19	11
5/-	46		2	12	15	11	6
7/6	20		2	5	7	3	3
10/-	18		1	11	2	2	2
15/-	19			8	3	5	3
20/-	8		2	2	3		1
very heavy drinkers	26	2	2	6	4	3	9

V. CONDITIONS OF WORK.

Despite the rich choice of causal factors in the production of arterio-sclerosis given in the summary above, it appeared evident that the field must be widened to obtain a satisfactory explanation of the extraordinary prevalence of the vascular condition shewn to exist in miners.

No single one of the causes enumerated, and no combination of these causes can apparently explain this frequency. Some factor common to all the cases remained to be ascertained, and attention was naturally directed, in this search, to the conditions of work.

In this connection, the words of Professor Jeaffreson, written in 1887, (26) may be quoted: "Roughly speaking a collier spends a great portion "of his time in a locality where there is practical-"ly no light, very little pure air, often much foul "air and dust, and combined with this a high moist "temperature. Under these circumstances miners "submit themselves to great physical exertions in a "cramped and unnatural position. When we add to "that the great changes atmospheric and otherwise, "to which they are exposed on leaving the mine, we "must admit we have an unusual combination of ele-"ments favouring disease, which cannot fail to be

"productive of many special maladies, some of which, "no doubt, remain to be recognised."

Many of these conditions have no doubt been changed for the better, but the occupation of a coal-miner cannot be regarded as other than unnatural. In this district the pits vary in depth from 600 feet to 2000 feet: they are ventilated by either the plenum or vacuum system, generally by means of large fans on the surface: in some cases helped by a fire burning in a brazier at the bottom of an upcast air-shaft.

By this means a current of air, amounting in the larger pits to fully 200,000 cubic feet per minute, is forced down the shaft, and distributed through the workings.

Though this seems a very large quantity, one must consider that there are at least 20 miles of underground roads in one large pit in this district.

These roads are made through the coal seams so that, speaking generally, the coal is first worked from the areas furthest away from the shaft. The roads vary in height from seven or eight feet at the pit bottom, to four feet near the working faces; and in breadth from about twelve feet to six feet. The sides and roofs of these roads are supported by "trees" or props of timber, which are sometimes so close together that they form an almost solid wall.

As the coal is worked out in any area, the strata left are supported by timber pillars so that these waste workings contain a vast quantity of decomposing wood. The practical importance of this fact will be noted later.

The air forced down the shaft is directed along these various roads, by a system of screens, stoppings, and doorways, to all the working faces, and is then returned to a separate shaft, known as the "upcast" shaft. (see plans ~~in Appendix III~~ at end.)

As the miner here works down the pit for eight hours each day, and remains in the pit during the whole of that period, it is obvious that the composition of the air which he is breathing for so considerable a portion of each day, is a matter of very great importance. So much is that the case, that Dr Tatham (4) in discussing the disparity in death-rates among coal-miners in different localities, goes the length of saying that the ventilation of the pit is the most important factor in explaining this.

I have therefore secured analyses of samples of the air from various parts of one of the pits in my district, which was selected as being a typical one, and not by any means the worst as regards its ventilation.

There is a proportion of fire-damp (CH_4) given off by the coal in certain seams of the pit, so that the ventilation there has to be specially efficient in the interests of safety.

These analyses are given in detail in the appendix(IV) They were made by E. Bessel Whalley, Esq., H.M.Inspector of Mines, by whose kind permission I have been enabled to quote them here.

The two abnormal constituents which we find in mine air are CH_4 and CO.

The CH_4 (methane or fire damp) is given off from coal, within which it is contained in a highly compressed state. Different seams of coal give off very different proportions of fire damp.

This fire damp is formed when organic substances are decomposed in the absence of air and in the presence of water. Enormous quantities of it may be contained in coal.

Though it is not recognised in text books, in this district CH_4 is certainly formed through the calcination of the coal, due to the proximity of igneous rock, a fact which is proved by the constant coincidence of partially burnt (semi-anthracitic) coal and fire damp. The fire damp here is therefore probably not pure Methane.

Fire damp has no direct action on man, it acts

simply as a diluent of the oxygen in the air; it is only present in comparatively few seams of coal in this district.

The other abnormal constituent of the air of mines is Carbon Monoxide. This is always due to imperfect combustion, and is therefore only present in exceptional circumstances, for example, when a seam of coal is burning, or when an explosion occurs, either of fire damp or as in No 7 sample in the list given (p 65.) after a shot has been fired during the process of coal getting.

CARBONIC ACID (CO_2)

The constituent present in mine air which seems to me to be of especial importance so far as this enquiry is concerned is CO_2, and it is interesting to note the amount present in different localities in the pit, and contrast it with the normal and "extraordinarily constant" amount present in the air above ground, i.e. .03%

ANALYSES - (percentages.)

Place of Observation.	CO_2.	O_2.	CH_4.	N.
1. At surface.	.03	20.94	0	79.03
2. Pit bottom.	.05	20.85	0	79.11
3. Intake air course. 1000 yards from bottom.	.15	20.59	.24	79.02
4. Working face in "five "foot" coal.	.30	19.84	1.62	78.24
5. Another working face.	.23	20.3	.85	78.62
6. Naked light Section. Working face.	1.35	19.29	0	79.36
7. Ditto. 15 minutes after a shot had been fired.	1.84	18.59	.06 (CO)	79.51
8. Lochgelly Splint return air course.	1.54	19.20	.02	79.24
9. Rise Lochgelly Splint (intake air course.)	.37	20.46	0	79.17
10. First working face in ditto. (Sample taken on pavement.)	4.56	13.13	.02	82.28
11. Ditto, but sample taken midway between roof and pavement. (men working.)	1.21	19.97	0	79.82
12. Ditto.	1.41	18.23	.10	80.26
13. Last "face" in section.	1.05	19.33	0	79.62
14. Return for whole section near shaft.	1.69	18.84	0	79.47
15. Total return air of pit, taken in shaft, 3 fathoms from the surface, in a current of 200,000 cubic feet of air per minute.	.21 .22	20.57 20.51	.13 .21	

It will be noticed that sample 2, taken at the pit bottom, already contained .05% CO2: while No 3, taken about 1000 yards from the pit bottom, and still before any working face was reached, contained .15 CO_2, the current of air passing along the road where it was taken being 3870 cubic feet per minute. The percentage of CO_2 at the actual working faces varied from .23 to 1.41.

Samples No. 3, 4 and 5 in the above table were taken in a section of the pit where safety lamps are used. The percentage of CO_2 present in these samples is much less than that in those following, and this is due not so much to any great difference in ventilation, but to actual difference in the quality of the coal. It is a matter of common knowledge among mining experts that coal which gives off CH_4 does not contain in its pores anything like the same quantity of CO_2, nor does it oxidise so readily as coal which does not contain CH_4. As the great majority of the miners in this district use naked lights at their work, the samples from 6 - 13 more nearly represent the average conditions of ventilation.

Sample No. 7 was taken 15 minutes after a charge of nitroglycerine (used in blasting out the coal) had been exploded, and it contained .06 CO.

It must be admitted that these figures are somewhat startling, and the importance of them is the greater as they do not represent bad ventilation from the mining standpoint.

The only statistics hitherto available of analysis of air of mines are those of Dr. Angus Smith and Dr. T. G. Nasmyth.

Dr. Nasmyth (Air of Coal Mines, loc. cit.) quotes Dr Smith as having obtained from 339 specimens of air an average of .785%, and he goes on to say, "no miner at the present time would be asked to "work in such an atmosphere, nor would he if asked."

His own average of results of analysis was as follows:-

In moderately deep mines 0.181% CO_2.

In mines over 100 fathoms 0.219% CO_2.

He states that these are exceptionally high results and that they do not represent the average condition of mines.

In view of the actual analyses which I have given, it is difficult to understand his statements. Indeed I have it on the authority of four mine managers, whom I have consulted on this point, that air containing .7% CO_2 represents "good ventilation" while the samples giving the higher percentage (1.35 and 1.41) are referred to by the miner himself as

"dull air," and it is notorious that men work in such an atmosphere for prolonged periods (months or even years) without raising any objections.

Such atmospheres have no appreciable effect on respiration, though in them a lamp will burn somewhat dimly: it is not until the percentage of CO_2 rises to about three, that it has any noticeable effect. But Mr W. Thomson F.R.S. Edinburgh F.I.C. has recently pointed out to the Manchester and Salford Sanitary Association (27) that the percentage of CO_2 in expired air depends on the quality of the surrounding air; and that "the air of a coalpit "about two thirds of a mile deep produced about 18% "less oxidising on the blood of the men working "there," than above ground.

The effect on lights is due to deficiency of Oxygen, and not to the actual percentage of CO_2 present, and a light (a tallow candle) only gradually goes out when the Oxygen is diminished to 17.6%. Under the usual conditions met with in mines, the diluent of the Oxygen is Black Damp, and the percentage of CO_2 would in these circumstances be about 2.2.

I was anxious to find out whether the higher figures given in the tables above, had any effect, per se, on Blood Pressure, Pulse rates and Respira-

tion. Accordingly half a dozen men were collected in the Colliery Office, and these particulars obtained. This (to them) unaccountable preceeding seemed to prove rather unsettling to some, so that the results obtained were not quite normal. My own Blood Pressure, etc., were then taken, and I then went down the pit with the men, and followed them to their work, about ¾ mile from the pit bottom. The road was a very bad one and at one point the lamps went out owing to the large amount of Black Damp, so that when we arrived at the working face, we rested for half an hour before making any further observations. The lamps here were decidedly affected, there being, according to the manager, about 1% CO_2 present.

The differences then noted were, slight slowing of the respiration, with increase in the pulse rate: no difference was noted in the Blood Pressure.

I then went with a small party to a place which was not being worked on account of the bad ventilation.

There the oil lamps burned dimly when held close to the roof, but were immediately extinguished on being lowered. It was impossible to get a match to light at all. I sat on the pavement for about 15 minutes: the difficulty of breathing was quite

noticeable, though the respirations were actually slower than they had been at the previous place or above ground (16 per minute as compared with 18 and 20 respectively.) The manager's respirations which had previously been 16, were now 14 per minute. The pulse rate remained the same as before (84, as compared with 72 above ground.) It was impossible to get a reading of the Blood Pressure as the light was too dim.

After the men had been working for some little time the same particulars were again noted, and the usual results after exertion were found, i.e. increased frequency of Respiration and Pulse rate, and increase of Blood Pressure, varying from 10 - 26 m.m. mercury.

The large percentage of CO_2 present in the air of a coal pit requires some explanation.

First it must be noted that in a mine there is no consumption of Carbonic Acid, on the contrary it is being produced. The increase is only to a very small degree due to respiration of men and horses, and the burning of lamps, though these are the only factors taken into account by Dr T.G.Nasmyth (loc. cit.), it is mainly due to the amount actually given off by the coal and to the oxidation of wood and the exposed surface of the coal.

The increased percentage already noted as being found at the bottom of the downcast shaft (.05) is due to the air passing over the timber with which the shaft is lined.

At one part of the workings 8000 cubic feet of air, containing 0.14% of CO_2, was passing per minute, and half a mile farther on, before reaching the working face, and no men, horses, or lights having been passed over, the same air contained 0.37% CO_2. In such a case the increase of CO_2 is obviously due to oxidation of coal and wood.

I am definitely of opinion that it is the inhalation, over prolonged periods, of air containing such abnormal quantities of CO_2 that is the cause of the almost universal arterial thickening which was found in my cases. And cases have come under my notice which indicate that a distinct difference may be detected in so short a period as three months. For example, G. McL., aet 15, was first examined on December 12th 1907. He had at that time been working down the pit for two months. His radial, when felt for with great care, could only be detected with the finger nail like a thick thread. It was entered as an "A" artery. On March 19th 1908, when again seen, his radial was cordlike, and <u>easily felt</u> with the pulp of the finger. It was then called "B-". His Blood Pressure on both occasions was 93.

Another similar case was that of P.L., first examined on November 27th 1907, when he had been working down the pit for 8 months. His radial could not then be felt at all, and was classified as "A." He was again seen on April 14th 1908, having been underground for one year; and his radial was then distinctly palpable, and cordlike, being a "B-" artery. His Blood Pressure was 105 on the first occasion, and 96 on the second.

DURATION OF OCCUPATION.

I have therefore tabulated the various groups of arteries in relation to the time during which the men have worked underground, giving the numbers of men in each group.

TABLE OF ARTERIES AND OCCUPATIONS.

Duration of work underground.	Total number	Condition of Radial Arteries. A.	B-	B.	B+	C	D.
I. 6 months and under.	21	13	5	3			
II. 7 months to 1 year.	23	8	10	5			
III. 1 - 2 years.	28	0	5	22	1		
IV. 2 - 3 "	30	1	10	17	2		
V. 3 - 4 "	34	3	8	21	2		
VI. 4 - 5 "	19	2	5	8	3	1	
VII. 5 - 6 "	26	3	5	16	2		
VIII. 6 - 7 "	21	1	6	10	3	1	
IX. 7 - 8 "	22	3	2	12	5		
X. 8 - 9 "	19	0	5	10	4		
XI. 9 -10 "	20		5	8	7		
XII. 10-15 "	54	1	17	21	14	1	
XIII. 16-20 "	58	5	11	20	22		
XIV. 21-25 "	32	3	7	14	7	1	
XV. 26-30 "	39	1	5	12	15	6	
XVI. 31-35 "	25		4	4	13	4	
XVII. 36-40 "	14			2	4	8	
XVIII. 41-45 "	6			1	3	2	
XIX. 46-50 "	5			2		2	1
XX. 51-55 "	3					2	1
XXI. 60 "	1					1	
	500	44	110	208	107	29	2

It is seen that of 44 men (I and II in above table) who had worked below ground one year or under, no fewer than 21 had normal arteries, equal to 48%, and these were not only boys, but varied in age from 14 up to 30. In no other grouping of my cases is it possible to get such a large percentage of "A" arteries.

There is a tendency to an increase in the amount of thickening of the arteries with the duration of occupation underground somewhat comparable to the previous tables shewing relation of arterial thickening to age, and this increase is already perceptible in the second group, those who have worked below ground between six months and one year, and it is very obvious in the group immediately following.

From this table it seems quite evident that work below ground, in coal mines, and under the conditions of ventilation shewn to prevail, has a definite relation to the prevalence of Arterio-Sclerosis in Coal Miners.

I believe that this Arterio-Sclerosis, with its subsequent results on general nutrition, accounts for the increased mortality of coalminers after the age of 55, as already mentioned (p.4). For although statistics may not shew conclusively that miners suffer from diseases of the circulatory system more than men in

other occupations, yet it is only to be expected that such an insidious pathological condition as Arterio-Sclerosis will in many cases fail to be recognised as the initial cause of death.

It is my experience, at least, to have met with many miners, dying at or about the age of 60 with all the symptoms of vascular degeneration; and I have frequently met with miners who, while not complaining specially of any circulatory disturbances, had the physical appearance, while still on the "right side" of 60, of having summed up their three score years and ten.

In this connection, I am indebted to Mr Telfer, Manager of Wilson's and Clyde Coal Co., Ltd., for obtaining for me the ages of all miners working at a small colliery in the district. This is a comparatively new colliery; and in his covering note, Mr Telfer says, "at this colliery there are very few 'on cost' "workers doing light work; at a larger and more fully "developed Colliery, there are more openings as 'roads-"men,' etc., for old men who have been miners, i.e. "men over 50 years of age."

In the list of 166 men whose ages were given me, there are only 3 of 50 years of age and upwards, while there are 22 aged between 40 and 50: the average age of the others is about 30.

The paucity of coal miners over 50 years of age may be more noticeable at this Colliery than at others but even allowing for that, the figures given bear out the contention that miners do suffer in some way as the result of the nature of their employment.

Indeed it is the expressed opinion of mining managers, that every year spent by a miner working in "dull" air (i.e. air containing from 1% to 1.5% CO_2,) shortens his life by another half year.

The results of the other points enquired into may be briefly dismissed.

The Pulse rate was taken in every case, but presented no points of interest.

A Blood count was made in 50 cases; and a Haemoglobin estimate made by Tallqvist's method: the figures obtained ~~are given in the Appendix, and~~ present no special features. The lowest count of Red blood Corpuscles was 4,210,000; there were 11 between that figure and 4,500,000; 25 were between $4\frac{1}{2}$ and 5 millions; and 14 were over 5 millions, the highest being 5,350,000.

The Haemoglobin varied from 75% to 100%. Only one was as low as 75%; 2 were 78%; 19 between 80 and 90%; and 28 between 90 and 100%.

These figures are all within normal limits in examining healthy individuals.

The following abnormalities were noted in the routine examination of the heart.

In 30 cases the Apex Beat was in the 5th intercostal space in the nipple line. The sounds were pure in all these cases.

The Blood Pressure was as follows:-

in 7 between 115 and 120.

in 7 between 120 and 130.

in 10 between 130 and 140.

in 6 between 150 and 160.

In other 10 cases the heart shewed still greater enlargement; and in them the Blood Pressure varied from 150 to 230 m.m.

Cardiac murmurs were only heard in 7 cases out of the 500.

In 6 of these, the murmur was Systolic, and at the Mitral valve: the heart in all was slightly hypertrophied, and the Blood Pressure was over 150 m.m.

The other was a Double Aortic murmur, and had a Blood Pressure of 185 m.m.

The condition of the Arteries in these cases of abnormality does not call for any remark.

N Y S T A G M U S.

Of the 500 miners examined, no fewer than 140 shewed distinct Nystagmus. While this condition varied greatly in severity, only one man had been unable to continue at work on account of it.

He was off work for 6 weeks, and gradually recovered, though he has still distinct oscillation on lateral deviation.

As Nystagmus is now scheduled as a "trade disease" under the Workmen's Compensation Act 1907, the recognition of its prevalence is important.

So far as I could make out, there seems to be no constant relation between the presence of Nystagmus, and any particular conditions of work down the pit.

Of the 140 cases, 85 had never worked with safety lamps, 55 had used them for varying periods.

29 gave a history of having worked more or less in "low workings," i.e. under 3 feet or 3 feet 6": 6 cases stated distinctly that they had always been in "high workings," i.e. over 5 feet. The others are noted as "average," i.e. from 3 feet 6" to 5 feet. Eight cases had never worked at the coal faces, but were "drawers", "fillers," and the like. One case was in a youth who suffers from Disseminated Sclerosis.

The ages of the cases varied from 14 to 68; and the duration of occupation from 4 months to 50 years.

While making the examinations during this research, any men who came into the surgery who were not miners, were examined, partly as a control. Of the 41 cases in this group, 20 had "A" arteries, which could not be palpated: these cases varied in age from 18 to 33. 10 had "B-" arteries: and varied in age from 16 to 64: 6 had "B" arteries, and varied in age from 34 to 72: only 3 had "B+", and 2 had "C" arteries.

There are no cases in this list at all corresponding to the group of miners under 20 years of age, shewing thickening of the arteries.

A table is given in Appendix II shewing cases chosen more or less at random, illustrating in each in detail, the various points which have already been discussed.

S U M M A R Y.

Of 500 miners examined, 91% had definitely palpable arteries, varying in thickness from "cordlike", to very thick, and tortuous. This thickening was present even in boys of 15 years of age.

The Blood Pressure in these cases did not vary directly with the thickness of the arteries.

Having discussed the aetiology of arterial thickening in miners, with special reference to the

conditions of ventilation of coal mines, I have come to the definite conclusion that the long continued inhalation of air containing comparatively large percentages of Carbonic Acid Gas, (1) is accountable for the prevalence of this arterial change.

Although the deductions which have been drawn from the facts established in this Thesis seem reasonable, it should be noted that it is difficult to generalise from them, for the reason that no similar work is available for comparison, in the meanwhile.

Possibly Arterial thickening is much more frequent than has usually been supposed. I am informed by Professor Stalker, of Dundee, that arterial thickening is very common among prisoners, even at early ages; and Clifford Allbutt, (Brit. Med. Jour. 1906, p.6) says "that the involutionary form of Arterio-"Sclerosis, associated with a continuously moderate "blood pressure, is common in agricultural labourers." So that it is quite possible that it may be common in other occupations as well.

Dr Russell's statement (loc. cit. p.28) that "be-"fore middle life it is fair to assume that uniform "thickening is mainly Hypertonic, unless Chronic "Brights Disease or Syphilis be present," is far too sweeping an assertion to make, until we have many more systematic records of the condition of Arteries

in men following different occupations.

The importance of Arterio-Sclerosis in coal miners from an economic point of view, especially with regard to the Workmen's Compensation Act, opens up a field for discussion which does not come under the scope of this thesis.

APPENDIX. I.

From Oliver's Dangerous Trades.

A. MORTALITY.

	All causes except accident.	Alcohol.	Liver Disease.	Phthisis	Resp. Dis.	Bright's Dis.	Accident.
Coal Miners	784	4	17	97	269	18	141
Farm Labourers.	590	4	13	115	129	12	42
Occup. Males.	897	13	27	185	221	27	56
Miners in Monmouth and Wales.	902	7	16	107	345	27	243

B. MORTALITY.

Age groups.	15	20	25	35	45	55	65 and up.
Occupied Males.	100	100	100	100	100	100	100
Coal Miners	150	111	86	77	94	119	143
Derby and Mott.	93	68	69	59	73	96	118
Monmouth and Wales.	227	141	118	97	117	140	129

APPENDIX II. CONTD.

CASES.

Case.	Age.	Duration of Occupation.	Artery	Maximum Blood Pressure	Amount spent on Alcohol per week.	Meat Consumption; per day.	Tobacco - per week.
A.H.	35	20	B+	128	5/-	¾lb.	2 oz.
T.W.	36	10 mos.	A.	140	10/-	1 lb.	3 oz.
J.M.	50	30 yrs.	B.	102	30/-	½ lb.	2 oz.
R.S.	28	16 "	B.	113	0	¼ lb.	0
R.W.	41	26 "	B+	105	0	¼ lb.	½ oz.
W.B.	38	16 "	B+	118	30/-	¼ lb.	3 oz.
J.C.	29	12 "	B-	115	15/-	1 lb.	7 oz.
D.T.	65	54 "	C.	112	60/-	¼ lb.	3 oz.
J.K.	28	11 "	B-	124	30/-	¾ lb.	2 oz.
W.A.	20	6 "	B.	115	1/-	½ lb.	0
J.McC.	22	9 "	B.	115	0	1 lb.	7 oz.
J.G.	35	18 "	B+	96	0	¼ lb.	0
T.Y.	30	4 "	B.	105	5/-	½ lb.	3 oz.
H.S.	31	11 "	B+	120	1/-	½ lb.	3 oz.
J.N.	22	10 "	B.	105	0	½ lb.	2 oz.
P.O'D	25	2 "	B-	125	30/-	½ lb.	4 oz.
D.M.	23	12 "	B+	115	0	½ lb.	0
J.C.	24	8 "	B.	120	15/-	½ lb.	3 oz.
S.S.	42	27 "	C.	120	2/6	¼ lb.	2 oz.
P.H.	18 "	3 "	B.	105	0	½ lb.	0
J.C.	45	30 "	B+	118	5/-	½ lb.	3 oz.
W.L.	25	9 "	B.	116	20/-	½ lb.	5 oz.
T.L.	46	33 "	B-	117	25/-	½ lb.	8 oz.
J.S.	33	12 "	C.	125	6d.	¼ lb.	2 oz.

APPENDIX II.

CASES.

Case.	Age.	Duration of Occupation.	Artery	Maximum Blood Pressure	Amount spent on Alcohol per week.	Meat Consumption; per day.	Tobacco - per week
W.K.	20	8 yrs.	B.	125	0	½ lb.	0
J.F.	24	7 mos.	A.	130	20/-	½ lb.	4 oz.
J.P.	41	3	B.	125	0	0	0
P.S.	31	9	B.	132	20/-	½ lb.	3 oz.
A.N.	17	4	B.	128	0	½ lb.	0
J.O'B.	33	20	B-	150	30/-	½ lb.	3 oz.
T.G.	29	18 mos.	B-	118	25/-	½ lb.	4 oz.
J.R.	35	22	B.	115	1/6	½ lb.	0
A.T.	23	7	B.	105	10/-	½ lb.	2 oz.
J.G.	19	8 mos.	B-	128	1/6	¼ lb.	2 oz.
J.McA.	46	30	B.	154	25/-	¾ lb.	3 oz.
C.S.	31	9	B-	155	6d.	½ lb.	2 oz.
A.L.	22	10	B.	112	0	¾ lb.	6 oz.
A.Y.	18	4	B.	115	0	½ lb.	2 oz.
N.C.	35	6 mos.	A.	155	5/-	1 lb.	1 oz.
M.H.	40	30 yrs.	C.	115	2/6	½ lb.	2 oz.
T.L.	38	24	B+	118	5/-	1 lb.	4 oz.
J.C.	19	6	B.	95	0	½ lb.	1 oz.
M.D.	28	11	B.	122	10/-	1 lb.	0
J.K.	21	4	B.	125	0	1 lb.	6 oz.
A.W.	37	24	B+	108	5/-	½ lb.	4 oz.
J.W.	18	2	B.	130	0	½ lb.	1½ oz.
W.R.	35	23	C.	125	0	¼ lb.	½ oz.
C.K.	26	12	B.	128	7/6	½ lb.	2 oz.
J.S.	36	13	B+	115	0	½ lb.	0
D.J.	17	4	B.	110	0	¼ lb.	0
A.C.	29	14	B.	113	10/-	¼ lb.	3 oz.

APPENDIX III.

REFERENCES.

1. Miners eight hours day Committee. Report 1907, Part 2.
2. Transactions of the Mining Institute of Scotland, Vol.X p.I - V.
3. Dangerous Trades, by Oliver, page 534.
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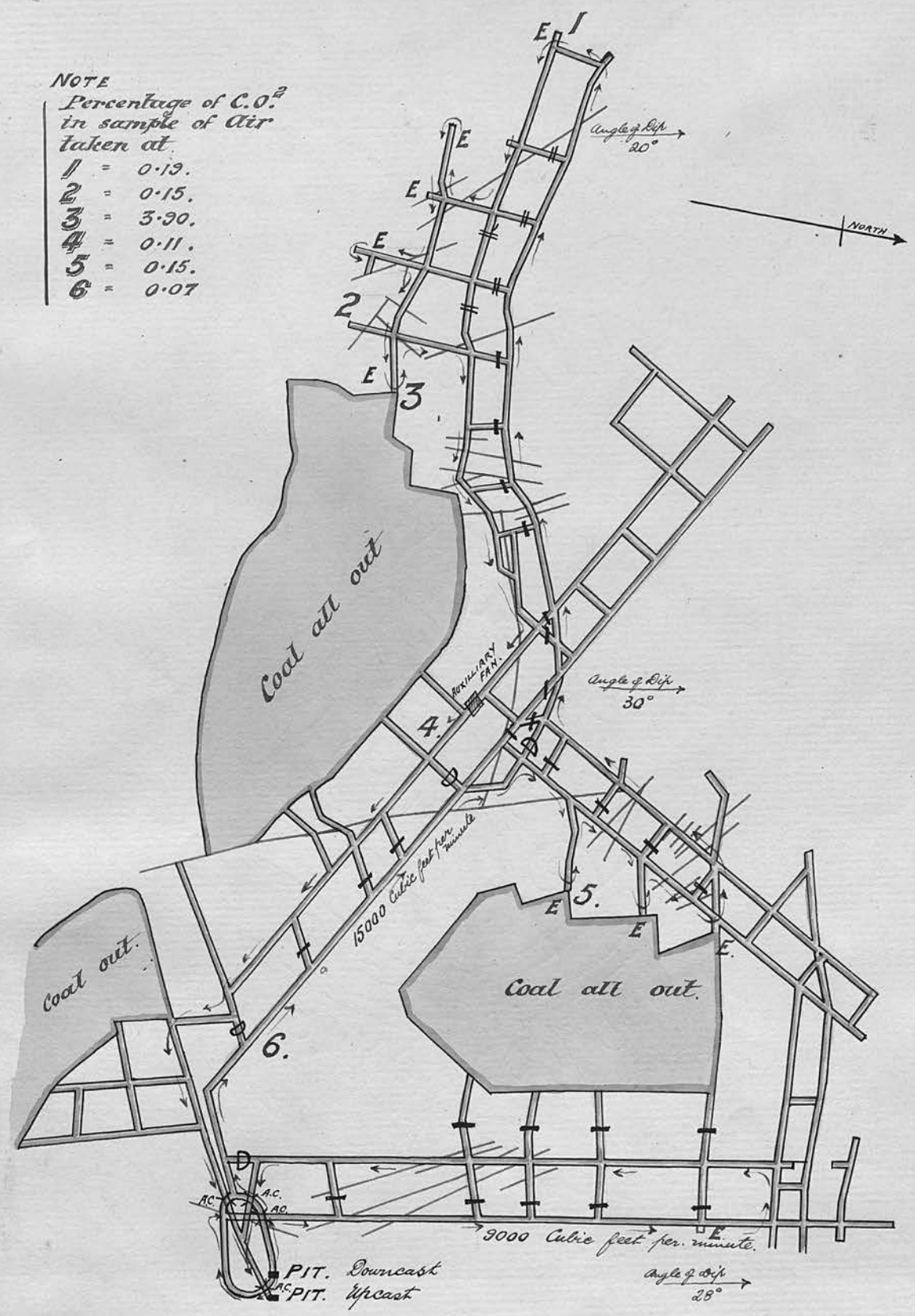
A P P E N D I X. IV.

Place of Observation.	Thermometer DRY	Thermometer WET.	Degree of Humidity.	Depth from surface (feet)	Distance from Shaft (feet).	Quantity of air passing per min.	No. of persons air has passed over.	No. of lights air has passed over.	ANALYSIS (Percentage). CO_2	O_2	CH_4	N_2
1. Surface	44.75	44.	94.						.03	20.93		79.04
2. Intake air course	52.25	51.75	96.7	1430	330	19,644 cub.ft.	3	0	.05	20.92		79.03
3. Do. (further in)	71.	66.	73.0	1733	2720	4,000	10	8	.15	20.59	.24	79.02
4. Working face.	72.	70.	89.0	1793	4386		12	10	.14	20.60	.58	78.68
5. Do.	75.	73.2	90.	1736	5409		37	36	.30	19.94	1.62	78.14
6. Do.	73. 1	71.	88.5	1727	2550		14	12	.23	20.30	.85	78.62
7. Return air course.	68.	65.	83.0	1465	6927	17,850	52	55	.13	20.57	.38	78.92
8. Intake air course	60. 5	59. 9	96.4			5,550	4	1				
9. Working face	70. 9	70.	94. 6	1417	2904		8	4	1.30	19.29		79.41
10. Do.				1382	3135		10	6	1.84	18.63	.03	79.50
11. Intake air course	64.	63. 3	95.8	1091	1650	6,640	1	1	.37	20.46		79.17
12. First working face in above.												
a. at pavement	68. 4	67. 5	94.6	870	3960		6	6	4.56	13.13	.03	82.28
b. at roof	"	"	"	"	"		"	"	.69	20.08	.02	79.21
c. at coalface	"	"	"	"	"		"	"	1.21	18.97		79.82
13. Another working face	71.	70. 1	94.6	790	4290		8	8	1.46	18.24	.10	80.20
14. Do.	68. 2	67. 0	92.8	835	4752		13	13	1.05	19.33		79.62
15. Return air.	67.	66. 5	97.0	1031	6666	2,800	20	20	1.69	18.84		79.47

Analysis otherwise expressed.			Composition of Black damp.		
Air	Black damp.	Fire damp.	CO_2	N_2	
99.95	.05		40.	60.	
98.38	1.38	.24	8.69	91.31	
98.42	1.00	.58	11.00	89.00	
95.27	3.11	1.62	8.68	91.32	
96.99	2.16	.85	9.25	90.75	
98.28	1.34	.38	7.46	92.54	
92.16	7.84		16.20	83.80	
89.01	10.96	.03	16.61	83.39	
97.75	2.25		15.12	84.88	
62.73	37.24	.03	12.22	87.78	*
95.94	4.04	.02	16.34	83.66	
90.64	9.36		12.61	87.39	
87.15	12.75	.10	11.29	88.71	
92.36	7.64		13.35	86.65	
90.01	9.99		16.62	83.38	

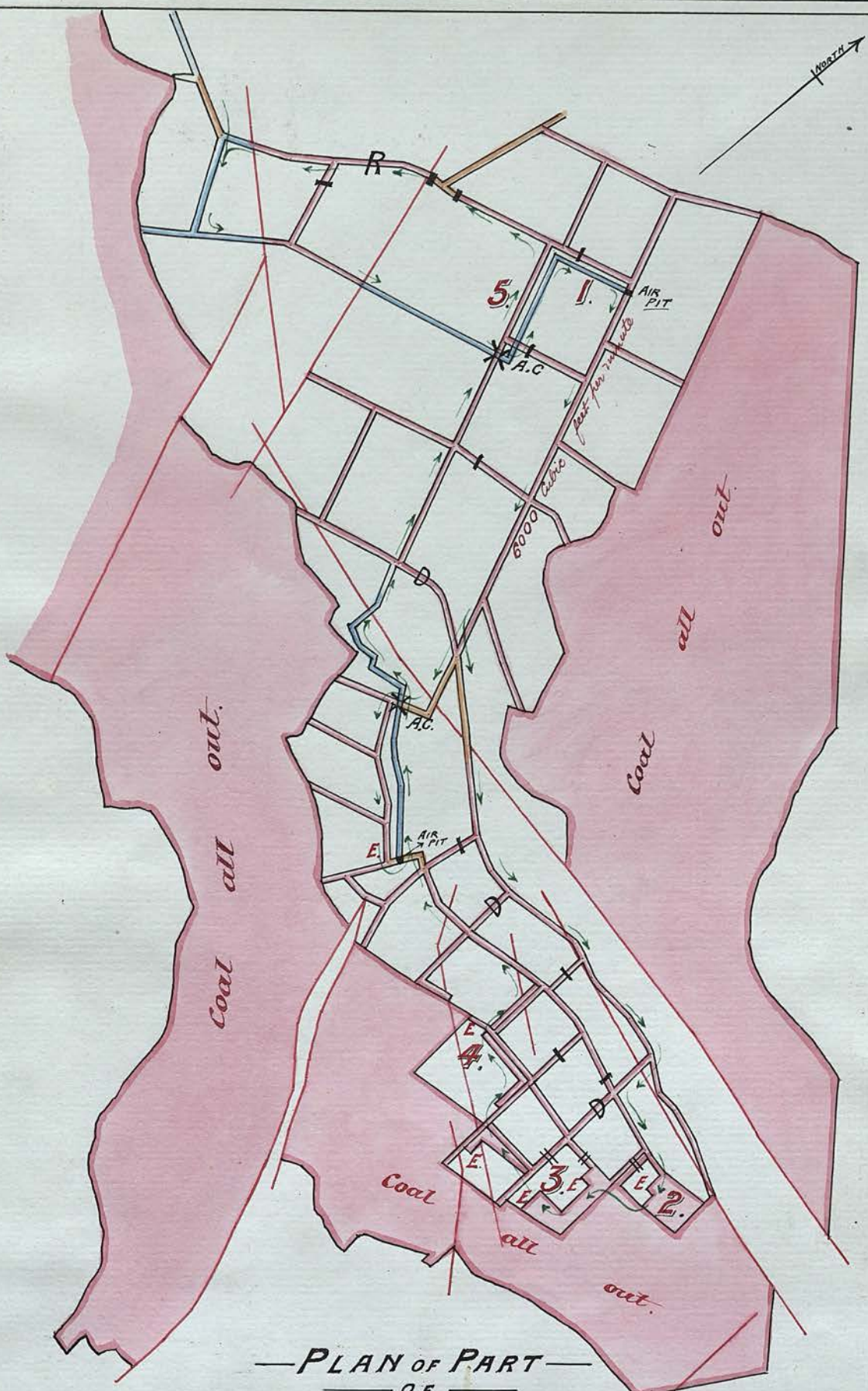


— PLAN OF PART —
— OF —
— THE WORKINGS IN ONE COAL SEAM —
— IN A —
FIFESHIRE COLLIERY

100 50 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300

Scale of Feet.

NOTE. Direction of Air Currents shown →. Stoppings shown —. Doors shown D. Canvas Doors =. Where one Air Current crosses another ⌅ A. C. . Roadways in solid coal ═══. Roadways in stone ═══. Faults shown ——. Coal being worked at points E.



PLAN OF PART OF THE WORKINGS IN ONE COAL SEAM IN A FIFESHIRE COLLIERY

100 50 0 100 200 300 400 500 600 700 800 900 1000

Scale of Feet

NOTE.

Direction of Air Currents shown →.
Stoppings shown —. Doors shown D.
Canvas doors shown =. Regulator shown R.
Where one Air Current Crosses another A.C..
Faults shown ——. Roadways in solid Coal ═══.
Roadways in a different Seam ═══. Roads in stone ═══.

NOTE
Percentage of $C.O^2$. in sample of Air taken at.

1. = 0·37. 2. = 1·21.
3. = 1·41. 4. = 1·05.
5. = 1·69.